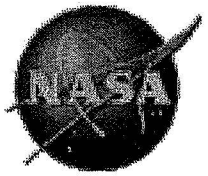
ISS Commercial Cargo Service:
Requirements & Constraints Summary

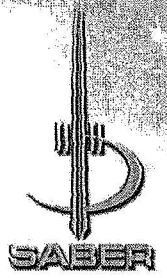


ISS Commercial Cargo Service Industry Day Conference

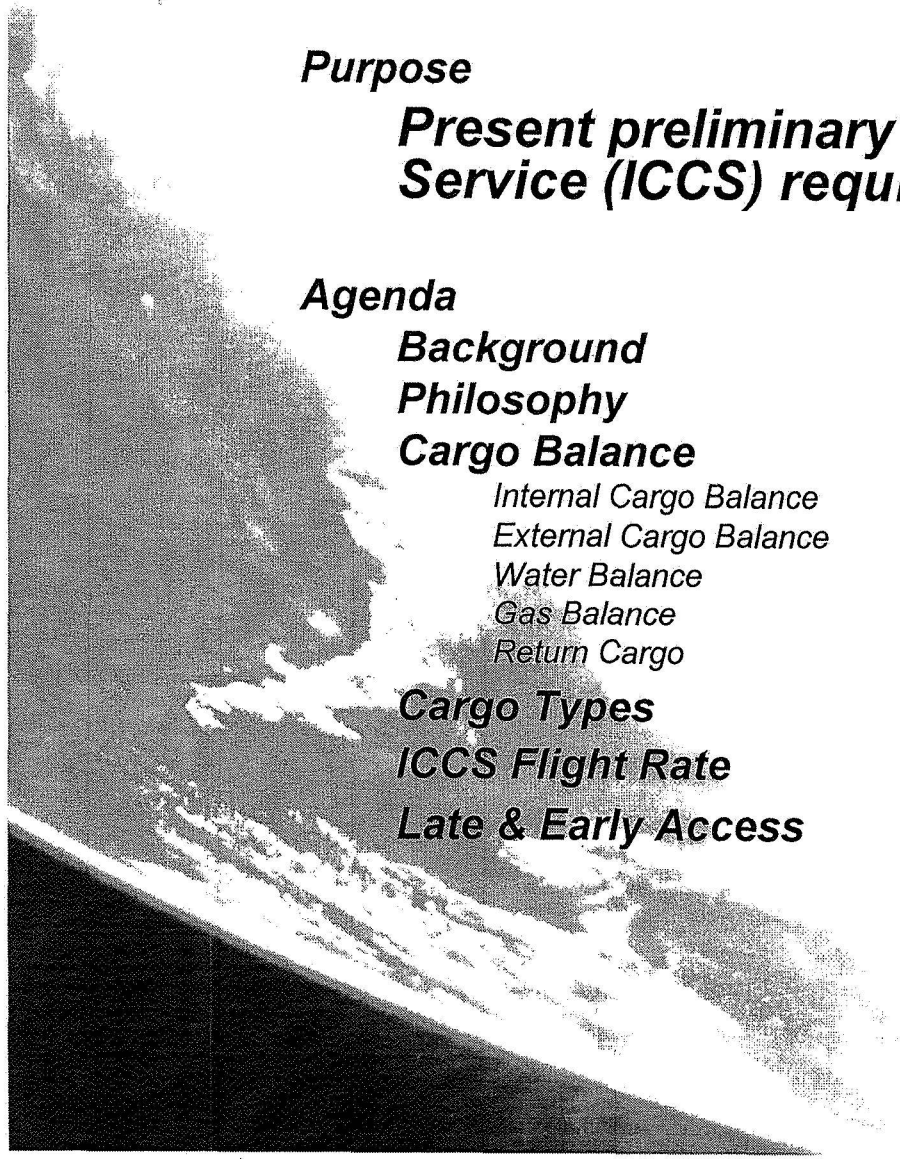
April 25, 2005

Valin Thorn
Neil Lemmons
Matt Scheutz

ISS Strategic Planning & Requirements Office
http://saber.jsc.nasa.gov
281.244.7097



Purpose & Agenda



Purpose

Present preliminary ISS Commercial Cargo Service (ICCS) requirements

Agenda

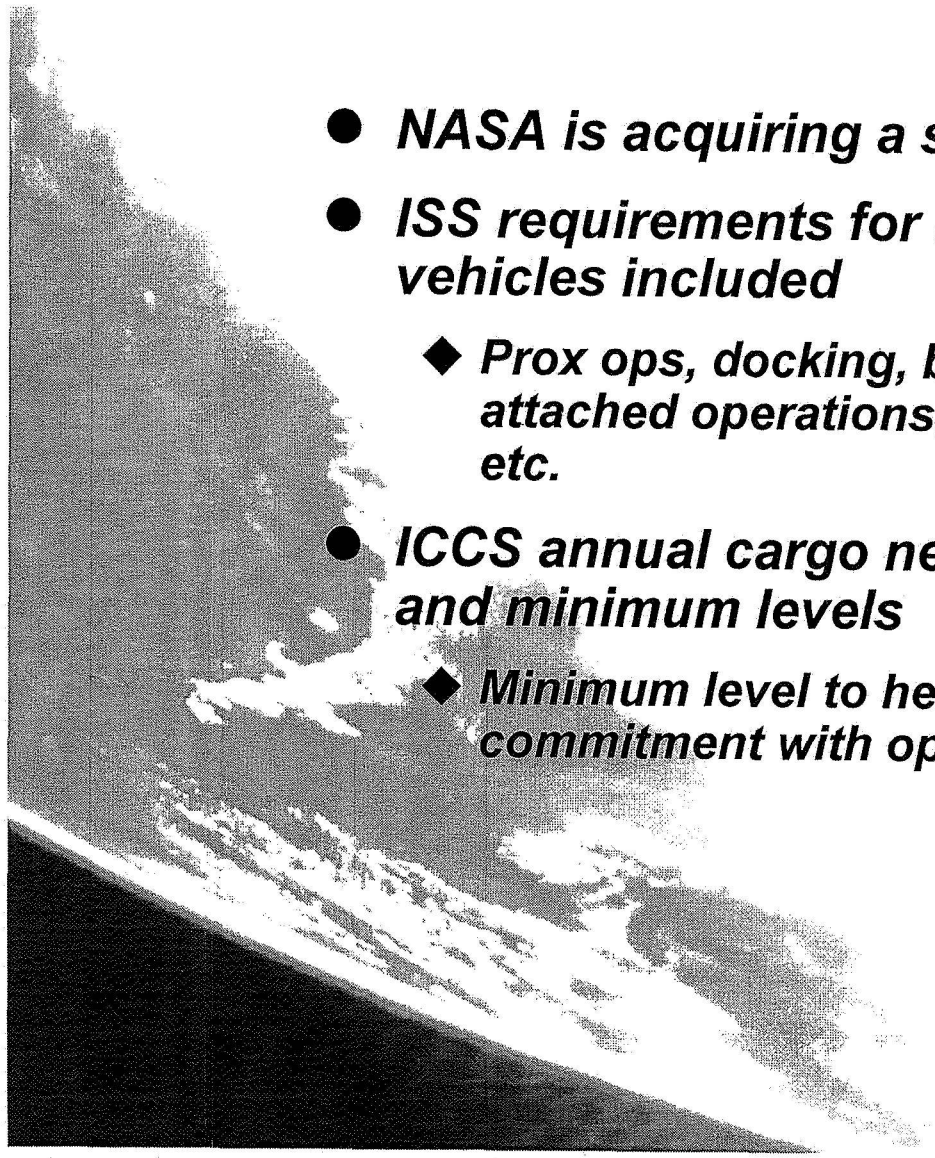
- ***Background***
- ***Philosophy***
- ***Cargo Balance***
  - *Internal Cargo Balance*
  - *External Cargo Balance*
  - *Water Balance*
  - *Gas Balance*
  - *Return Cargo*
- ***Cargo Types***
- ***ICCS Flight Rate***
- ***Late & Early Access***
- ***Power to Payloads***
- ***Mating Location Options***
- ***ISS Docking & Berthing***
- ***Vehicle Stay Time***
- ***ISS Resource Availability***
- ***Robotic & EVA Compatibility***
- ***Return Cargo***
- ***Key Req's Summary***
- ***Conclusion***

DRAFT

Background

- ISS commercial cargo transportation services will compensate for some cargo lost from Shuttle retirement in December 2010
- The NASA Launch Services Program Office (LSPO) at KSC is leading the acquisition effort with ISS assistance
- ISS preliminary requirements provided to LSPO (March 15th) for ICCS Draft RFP preparation
- ICCS requirements revision expected before Draft RFP release

DRAFT



Philosophy

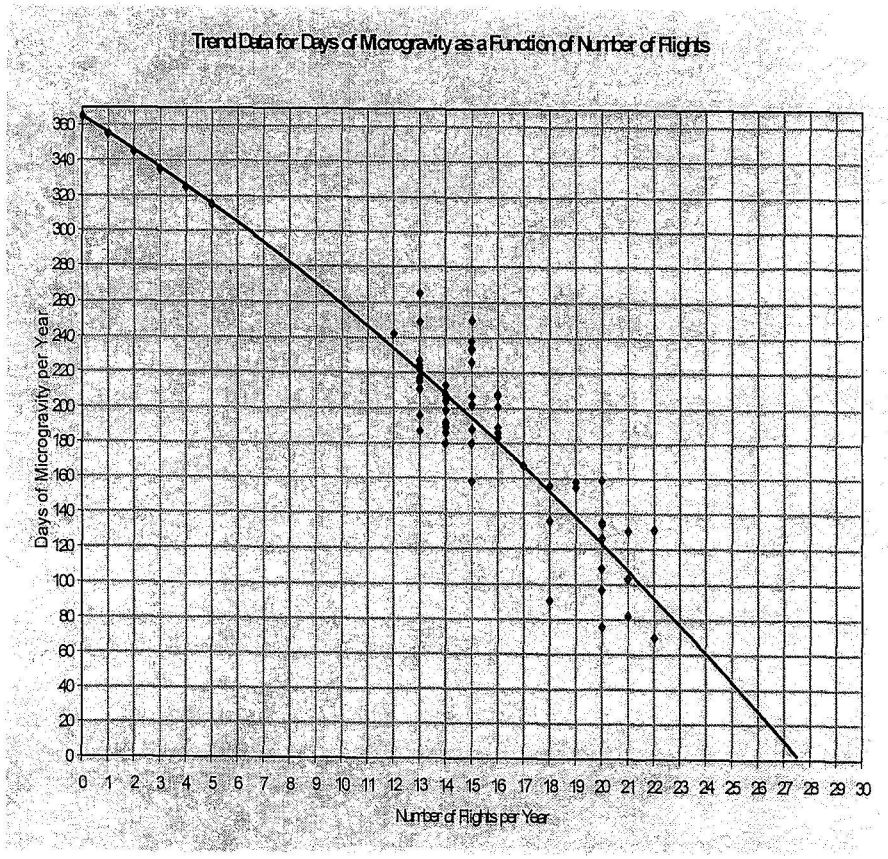
Service vs. Spacecraft Acquisition

- NASA is acquiring a service, not spacecraft
- ISS requirements for integration of visiting vehicles included
  - Prox ops, docking, berthing, robotics, interfaces, attached operations, resource availability, safety, etc.
- ICCS annual cargo needs specified – maximum and minimum levels
  - Minimum level to help set contract firm commitment with options for additional service

DRAFT

ICCS Cargo Vehicle Flight Rate

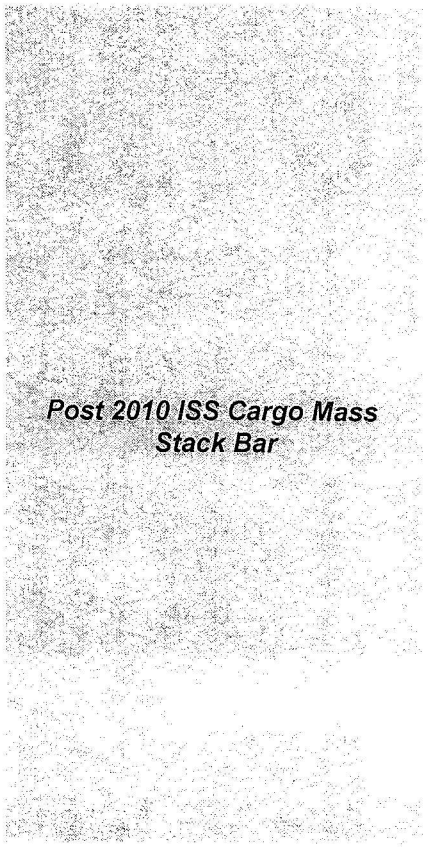
- ICCS vehicle flight rate limited to 6 flights/year
  - Crew time impact for arrival and departure operations
  - Impact to micro-g operations, still important to ISS partners
  - Soyuz, Progress, ATV, HTV vehicles visit 10 to 12 times / year in total
- ICCS must be able to respond to a cargo service request within 180 days
  - Unexpected need for crew supplies, maintenance, utilization, etc.



DRAFT

ISS Cargo Categories

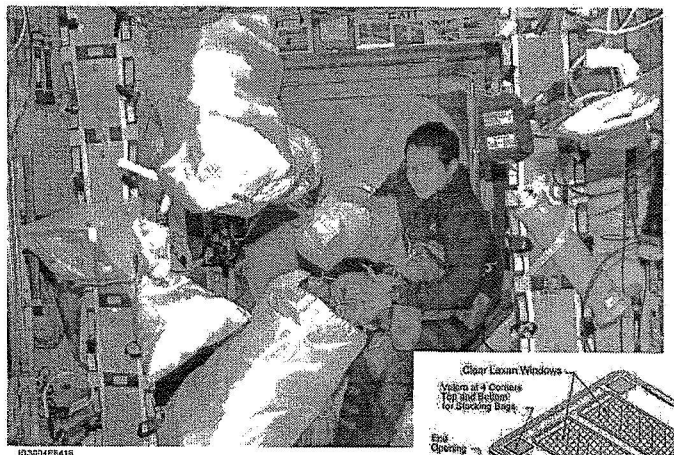
- Assembly hardware
  - Not ICCS requirement
- Crew Supplies
  - Food
  - Water
  - Gas
  - Flight crew equipment
- Maintenance
  - Internal & external ORUs
    - Preventative and corrective maintenance
- Utilization/Research
  - Research equipment, experiments
  - Laboratory consumables



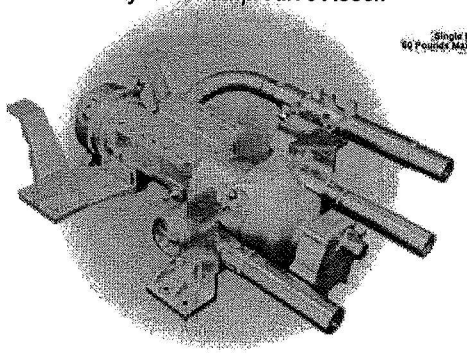
DRAFT

Cargo Packaging

- Rack delivery <u>not</u> required
- Internal cargo usually in soft sided stowage bags
- Large external ORUs – CMGs, TCS pumps, etc.
  - TCS radiators excluded because of spares already in orbit and projected need
- Experiment packages
  - Express rack elements



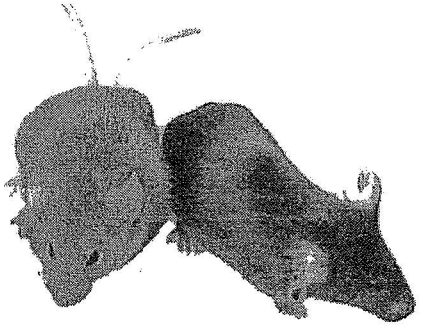
Thermal System Pump/Valve Assen

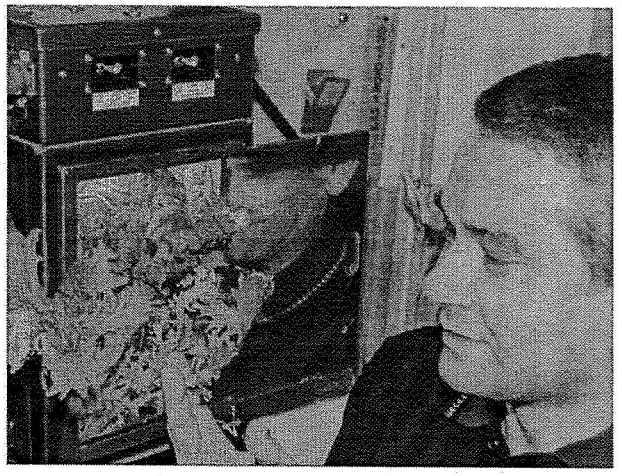


DRAFT

Late and Early Cargo Access

- ***Various payloads, such as plants and animals require late loading into the cargo vehicle***
  - *Cargo service/vehicle should provide cargo access as late as 19 hours before launch*
- ***Returning payload specimens and samples will need to be removed from the cargo vehicle shortly after landing***
  - *The cargo service/vehicle should provide the capability to remove the payload from the cargo vehicle within 4 hours after returning to Earth*





DRAFT

Power to Payloads

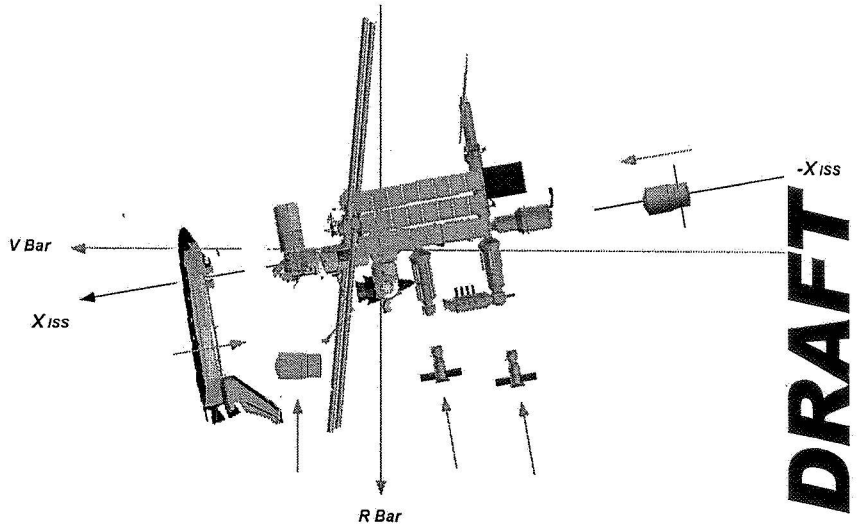
- ICCS payload power requirements during transportation
  - 500 W average
  - 1500 KW peak
  - Return power assumed to equal delivery power needed

Example Payload:
Commercial Generic Bioprocessing Apparatus

DRAFT

ISS Rendezvous, Prox Ops, Docking, Berthing Aids

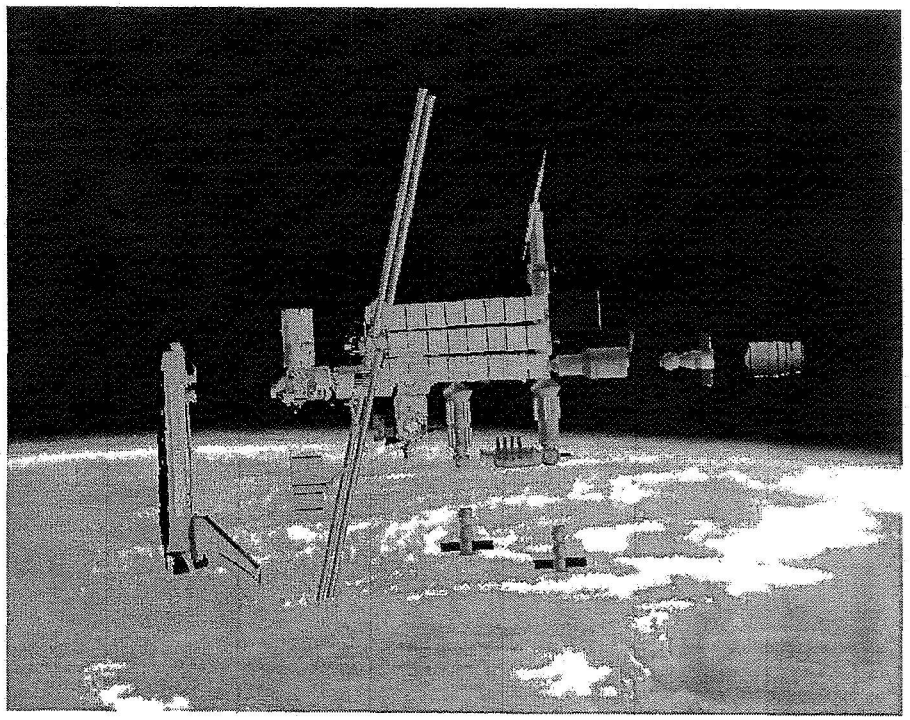
- No existing automated rendezvous & docking system to US segment
  - ISS only provides visual aids for Shuttle prox ops/docking
  - ICCS provided AR&D system for ISS is an available solution option
- HTV automated rendezvous to robotic capture and berthing
  - DGPS & TCS navigation
  - R-Bar approach to ISS nadir capture box – robotic berthing to Node 2 nadir
- Soyuz, Progress, and ESA ATV vehicles use Russian RF based, rendezvous & docking system
  - Applicable for dockings to ISS Russian segment
    - Service Module (SM) aft
    - SM/Docking Compartment nadir
    - FGB nadir



DRAFT

ISS Flight Attitude

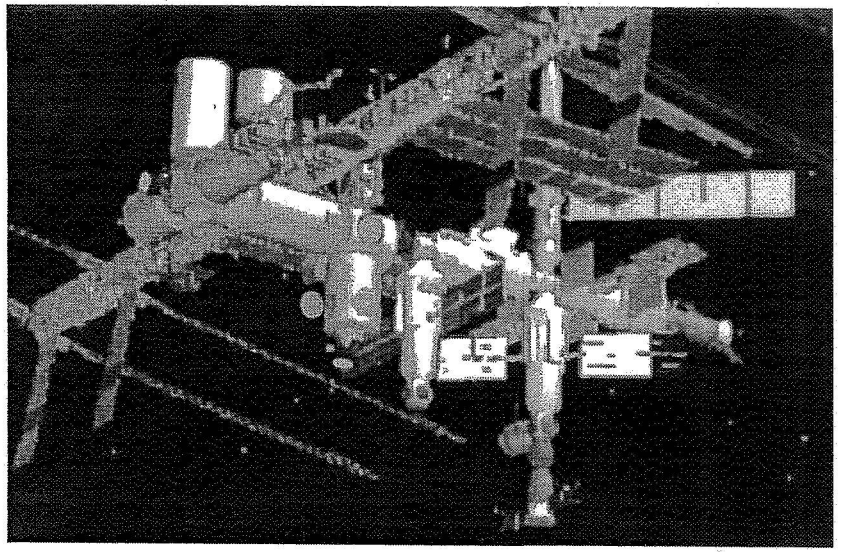
- **ICCS vehicles must dock and mate with the ISS in its normal operational flight attitude**
  - **X VV Z Nadir TEA**
    - *X body axis on velocity vector*
    - *Z body axis down/nadir*
    - *TEA – Torque Equilibrium Attitude*



DRAFT

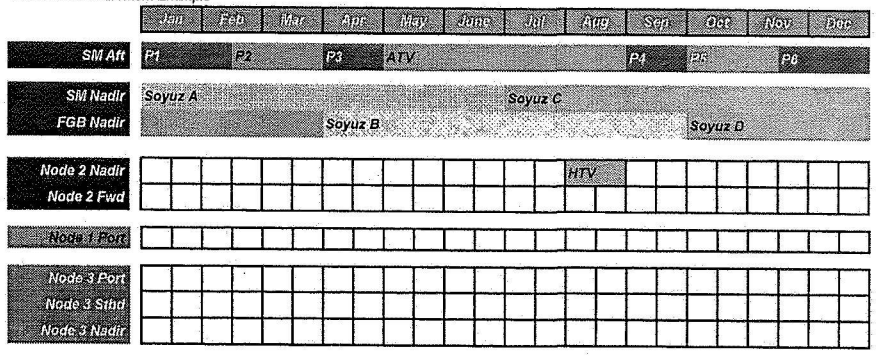
ISS Mating Location Options

- **ISS has six candidate ports available for attaching ICCS vehicles**
  - **The ports on the Russian Segment will be occupied continuously with Soyuz, Progress, and ATVs**
    - *Additional vehicles can visit these ports but will decrease the docked time of the Progress and ATV*
  - **The US Segment's ports have low occupancy rate**
  - **Attaching to the US Segment offers more flexibility**



ISS Vehicle Traffic & Port Utilization

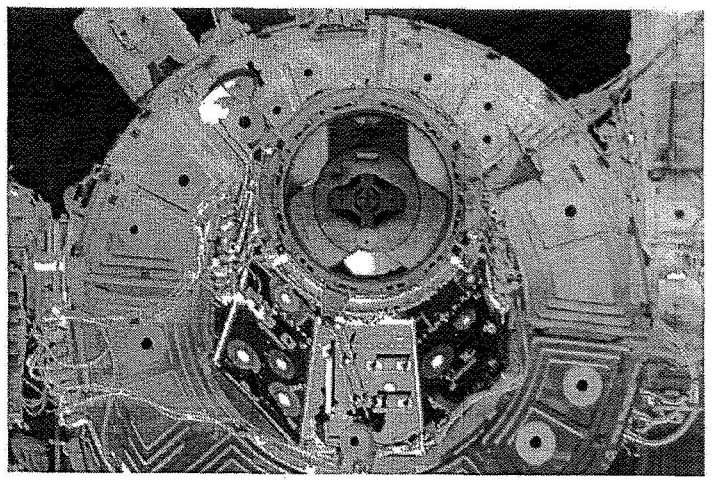
Post Shuttle Retirement Example



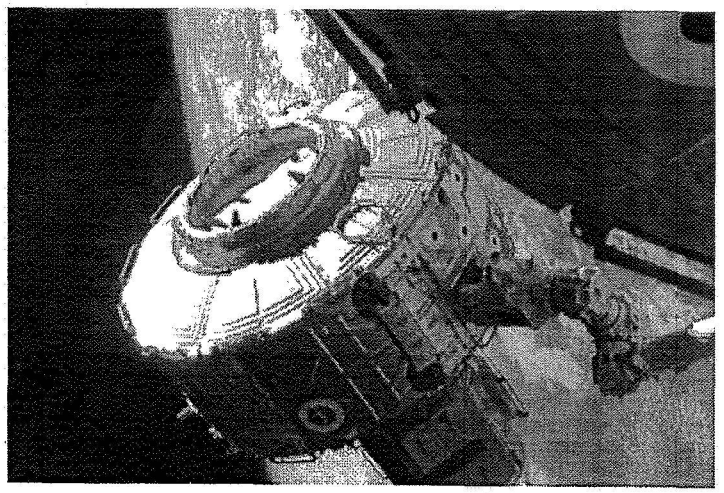
DRAFT

ISS Docking & Berthing

- ISS dockings to US Segment use Russia's Androgynous Peripheral Attachment System (APAS)
  - +X Body: PMA2
  - +Z Body: PMA3
- ISS module interfaces use Common Berthing Mechanisms (CBMs)
  - ISS robotic capture & mating only
  - MPLM, HTV



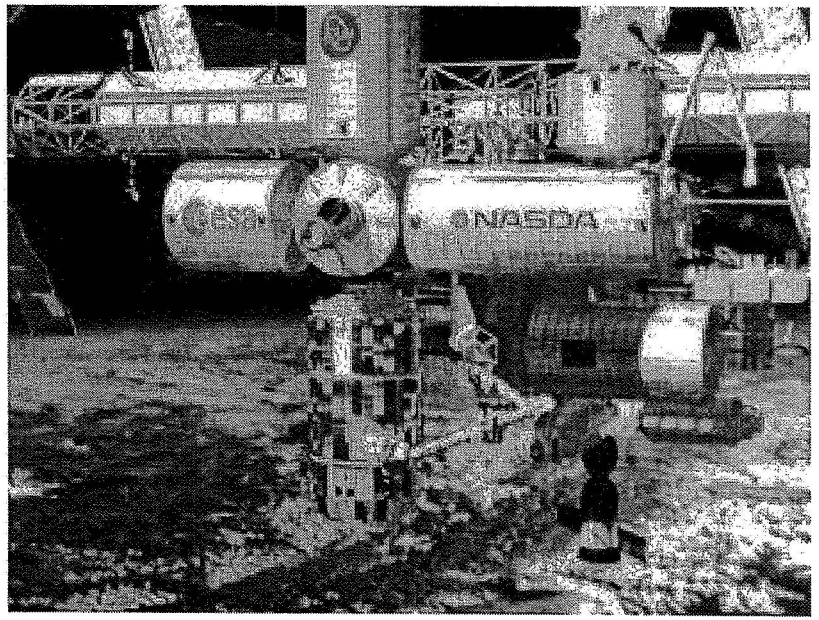
APAS on PMA



CBM on Airlock Module

Vehicle Stay Time

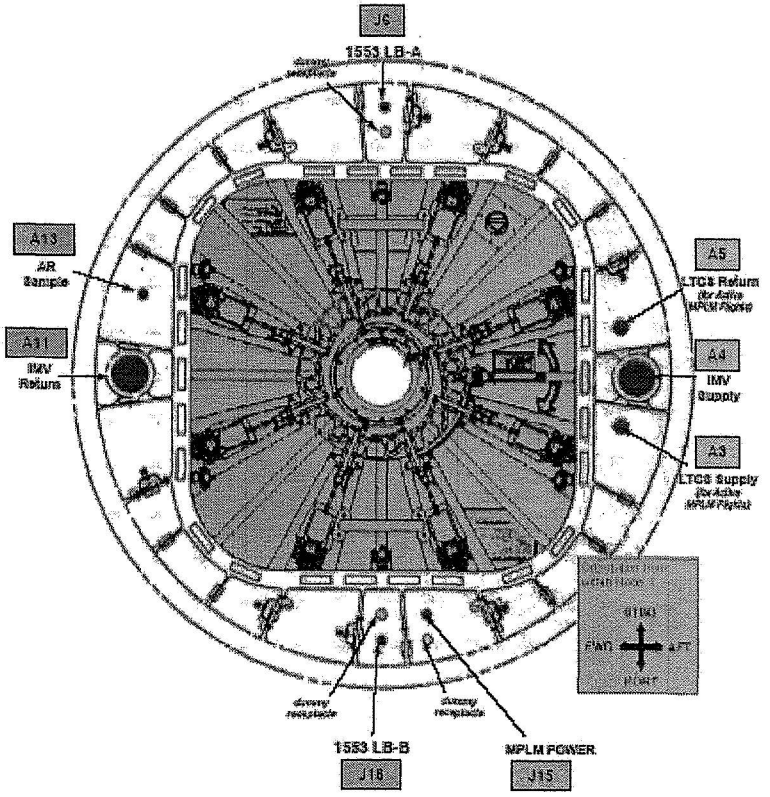
- ICCS vehicles must be capable of staying at the Station at least 7 days
  - Minimum time required to handle cargo transfer operations
  - Results of recent HTV studies may increase this minimum time
- Maximum stay time dependent on ISS operational vehicle traffic and port utilization plans
  - Longer stay time improves operational flexibility



DRAFT

ISS Resources for ICCS Vehicles

- **Power**
  - Allocation of 500 W average, 1500 W peak for ICCS
  - Typically 3 KW capacity
- **Thermal**
  - Thermal water loops available at Node 2 Nadir, Node 3, and Node 1 port side CBMs
    - ~ 3 KW capacity
  - Allocation of 500 W average heat rejection
- **Inter-module ventilation**

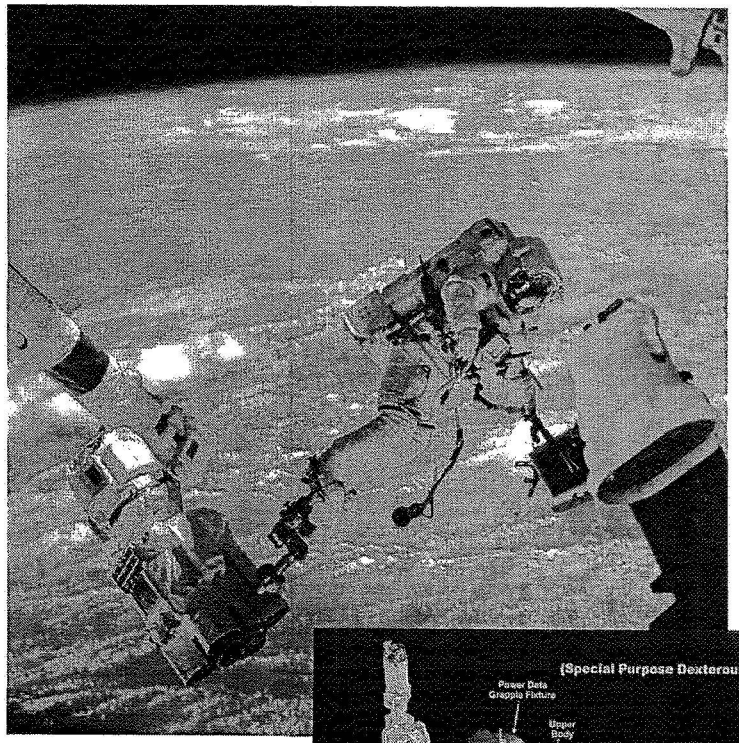


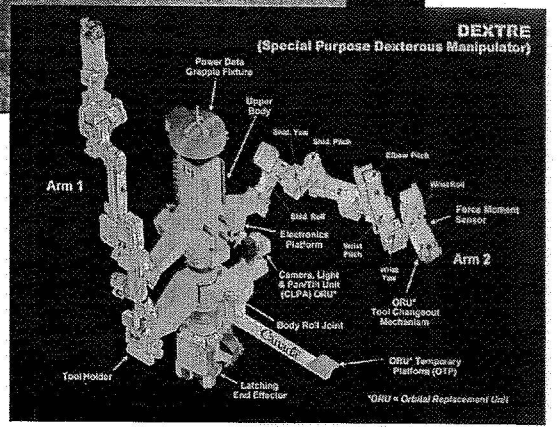
Typical Interfaces at CBM Vestibule

DRAFT

Robotic & EVA Compatibility

- ICCS external cargo must be compatible with ISS US Segment robotic systems and EVA handling
  - SSRMS
  - Special Purpose Dexterous Manipulator (SPDM/Dextre)
  - Mobile Transporter

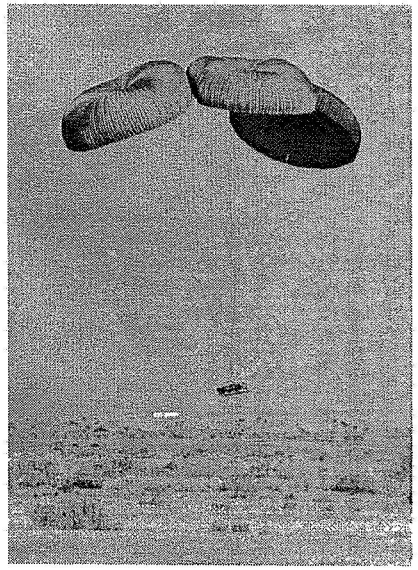




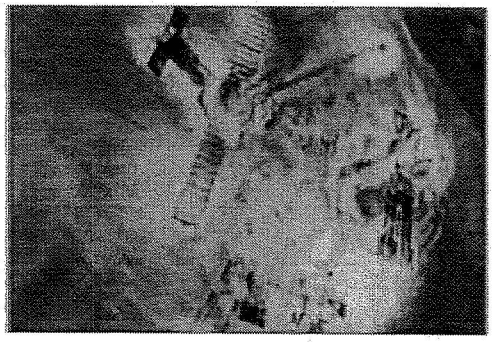
DRAFT

Cargo Return & Disposal

- **ICCS vehicles must have the capability to safely return cargo to Earth**
  - Internal cargo: 11 MT/yr max, 1 MT/yr min
  - External cargo: 3.3 MT/yr max, 0 min
  - Return cargo delivery to NASA within 14 days of landing
    - ☞ 4 hours for critical cargo
- **Cargo disposal required for large portion of ISS cargo**
  - Safe disposal requirements for expendable vehicles must be satisfied
  - Internal cargo: 8.3 MT/yr max, 400 kg/yr min
  - External cargo: 2.2 MT/yr max, 1400 kg/yr min



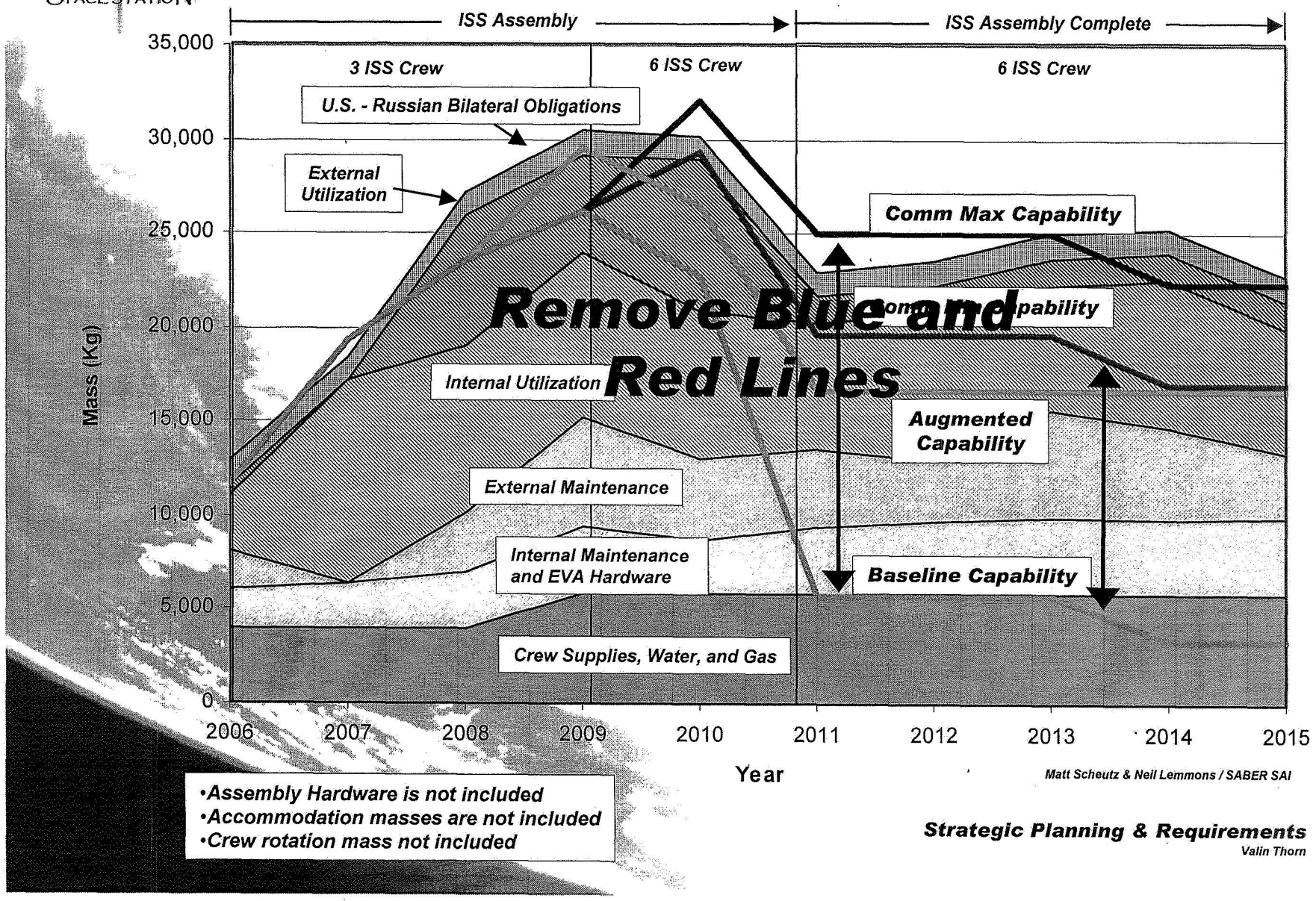
Cargo Recovery



Destructive Entry

DRAFT

ISS Cargo Supply Balance



Remove Blue and Red Lines

DRAFT

- Assembly Hardware is not included
- Accommodation masses are not included
- Crew rotation mass not included

Matt Scheutz & Neil Lemmons / SABER SAI

Strategic Planning & Requirements
Valin Thorn

Philosophy

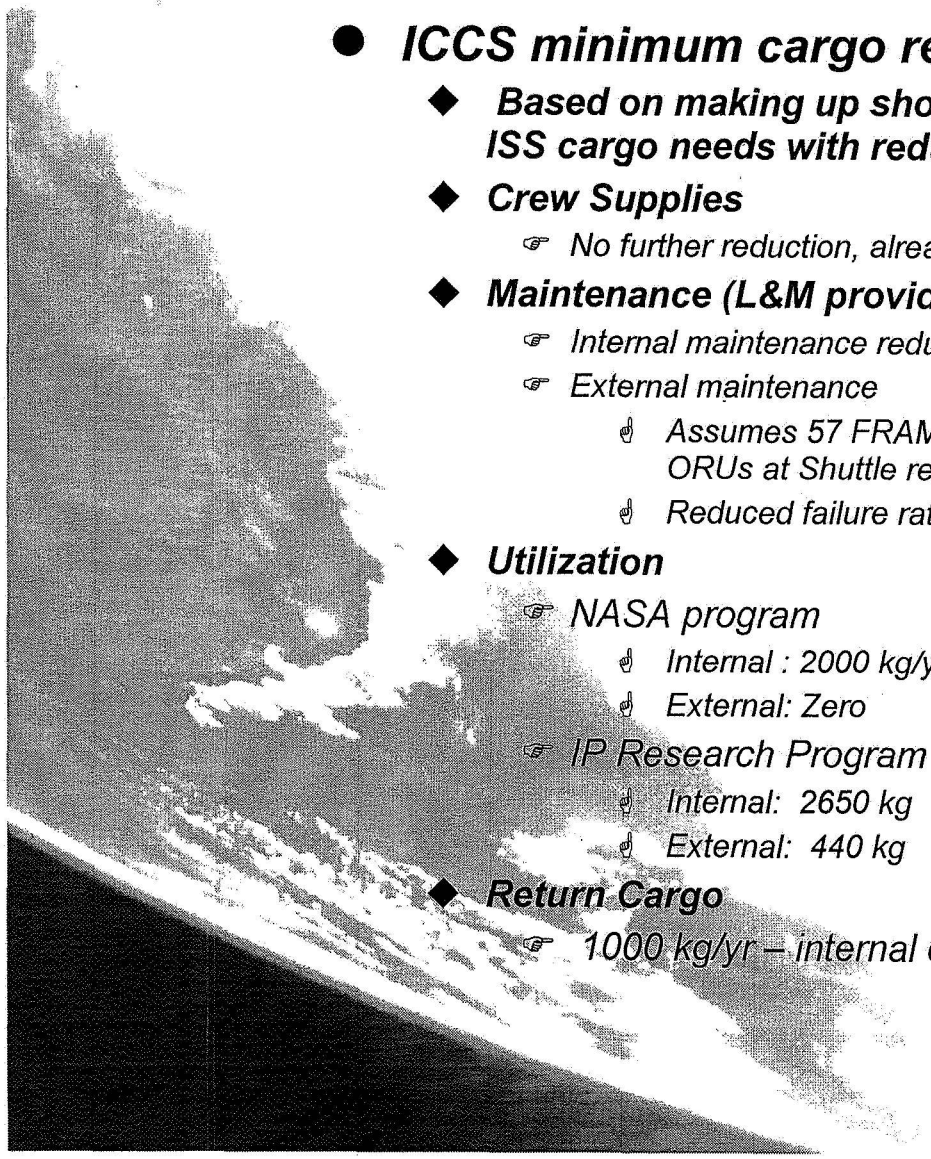
Maximum Cargo Requirements

- **ICCS maximum cargo requirements**
  - **Based on making up shortfall from baseline partner cargo delivery contribution**
  - **Includes latest available updates in need for crew supplies, maintenance, utilization, gas, & water**
    - *New NASA ISS USOS utilization requirements official update expected in coming weeks from ESMD – preliminary requirements received recently*
  - **Return Cargo**
    - *Maximum return capability of ~15,000 kg/yr*

DRAFT

Philosophy

Minimum Cargo Requirements

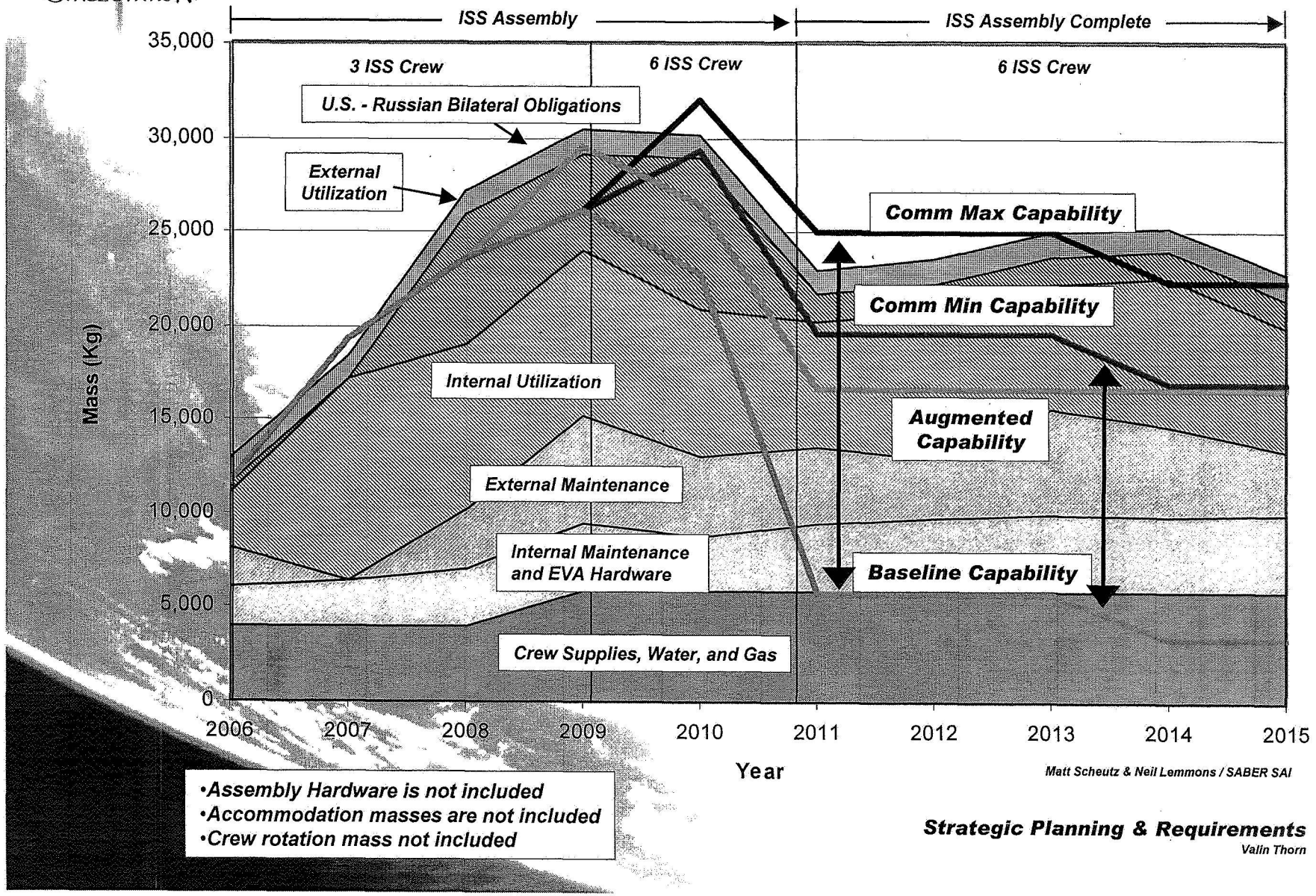


- ***ICCS minimum cargo requirements***
  - ***Based on making up shortfall from baseline partner contributions and ISS cargo needs with reductions in maintenance & utilization***
  - ***Crew Supplies***
    - *No further reduction, already at minimum acceptable level*
  - ***Maintenance (L&M provided minimum requirement)***
    - *Internal maintenance reduced 20%*
    - *External maintenance*
      - *Assumes 57 FRAM Eq of pre-positioned maintenance/spare ORUs at Shuttle retirement*
      - *Reduced failure rates*
  - ***Utilization***
    - *NASA program*
      - *Internal : 2000 kg/yr internal cargo delivery*
      - *External: Zero*
    - *IP Research Program*
      - *Internal: 2650 kg*
      - *External: 440 kg*
  - ***Return Cargo***
    - *1000 kg/yr – internal cargo only*

DRAFT

ISS NASA/JAXA/ESA/CSA

Cargo Demand/Delivery Balance Summary



- Assembly Hardware is not included
- Accommodation masses are not included
- Crew rotation mass not included

Matt Scheutz & Neil Lemmons / SABER SAI

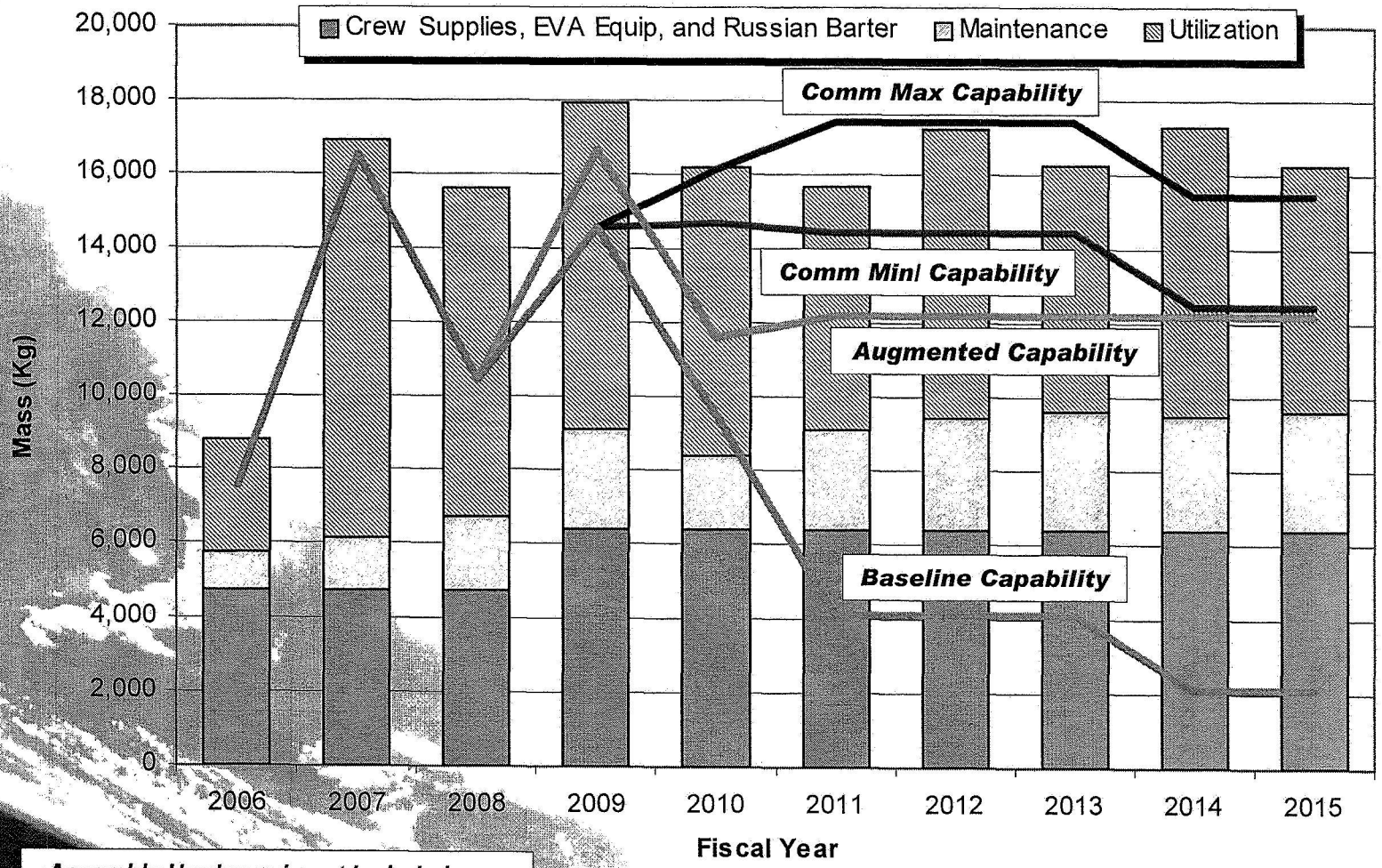
Strategic Planning & Requirements

Valin Thorn

DRAFT

ISS NASA/JAXA/ESA/CSA Cargo

Internal Demand/Delivery Balance



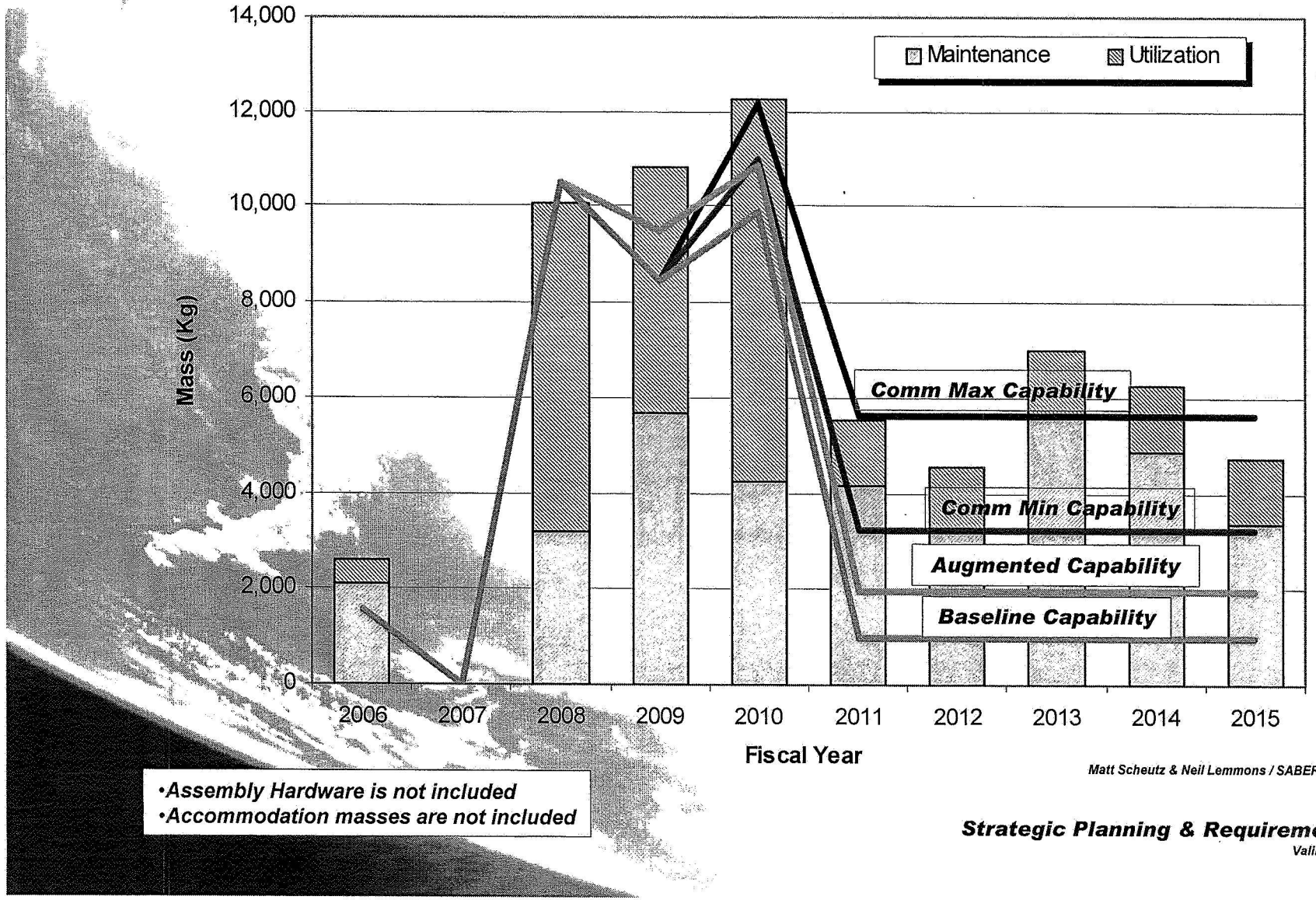
- *Assembly Hardware is not included*
- *Accommodation masses are not included*
- *Crew rotation mass not included*

DRAFT

Matt Scheutz & Neil Lemmons / SABER SAI

ISS NASA/JAXA/ESA/CSA Cargo

External Demand/Delivery Balance



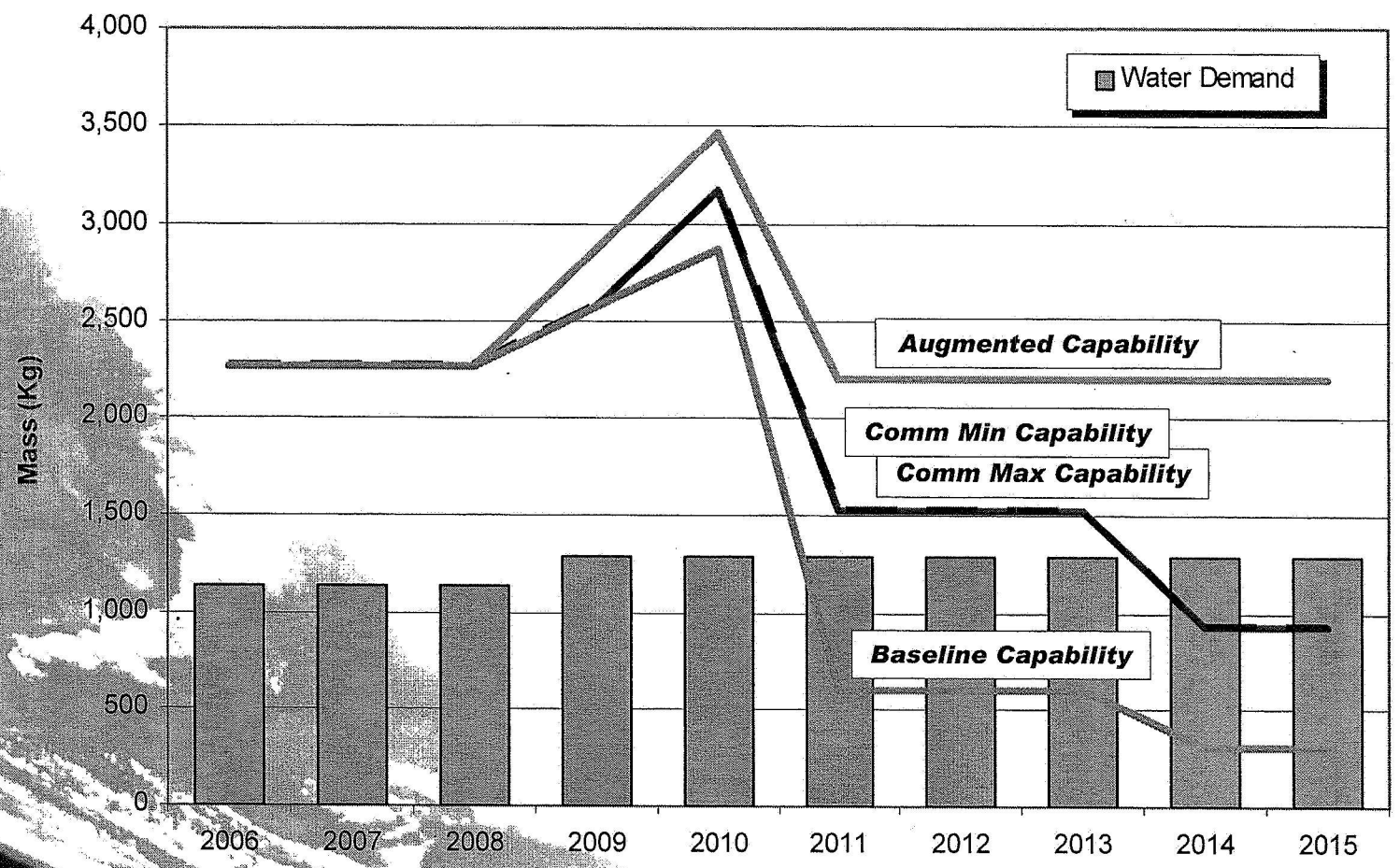
- *Assembly Hardware is not included*
- *Accommodation masses are not included*

Matt Scheutz & Neil Lemmons / SABER SAI

Strategic Planning & Requirements
Valin Thorn

ISS NASA/JAXA/ESA/CSA Cargo

Water Demand/Delivery Balance



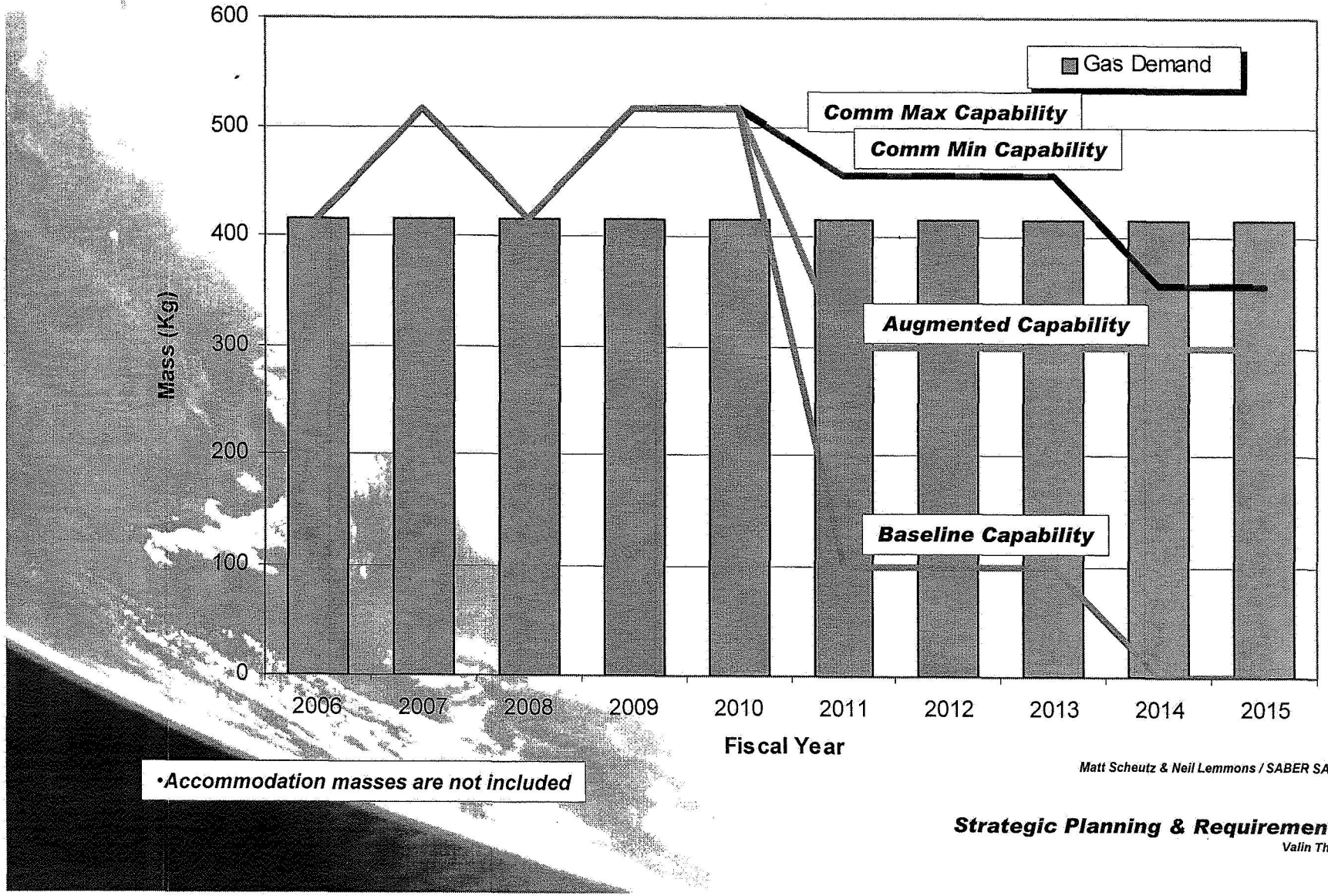
•*Accommodation masses are not included*

Matt Scheutz & Neil Lemmons / SABER SAI

Strategic Planning & Requirements
Valin Thorn

ISS NASA/JAXA/ESA/CSA Cargo

Gas Demand/Delivery Balance



•Accommodation masses are not included

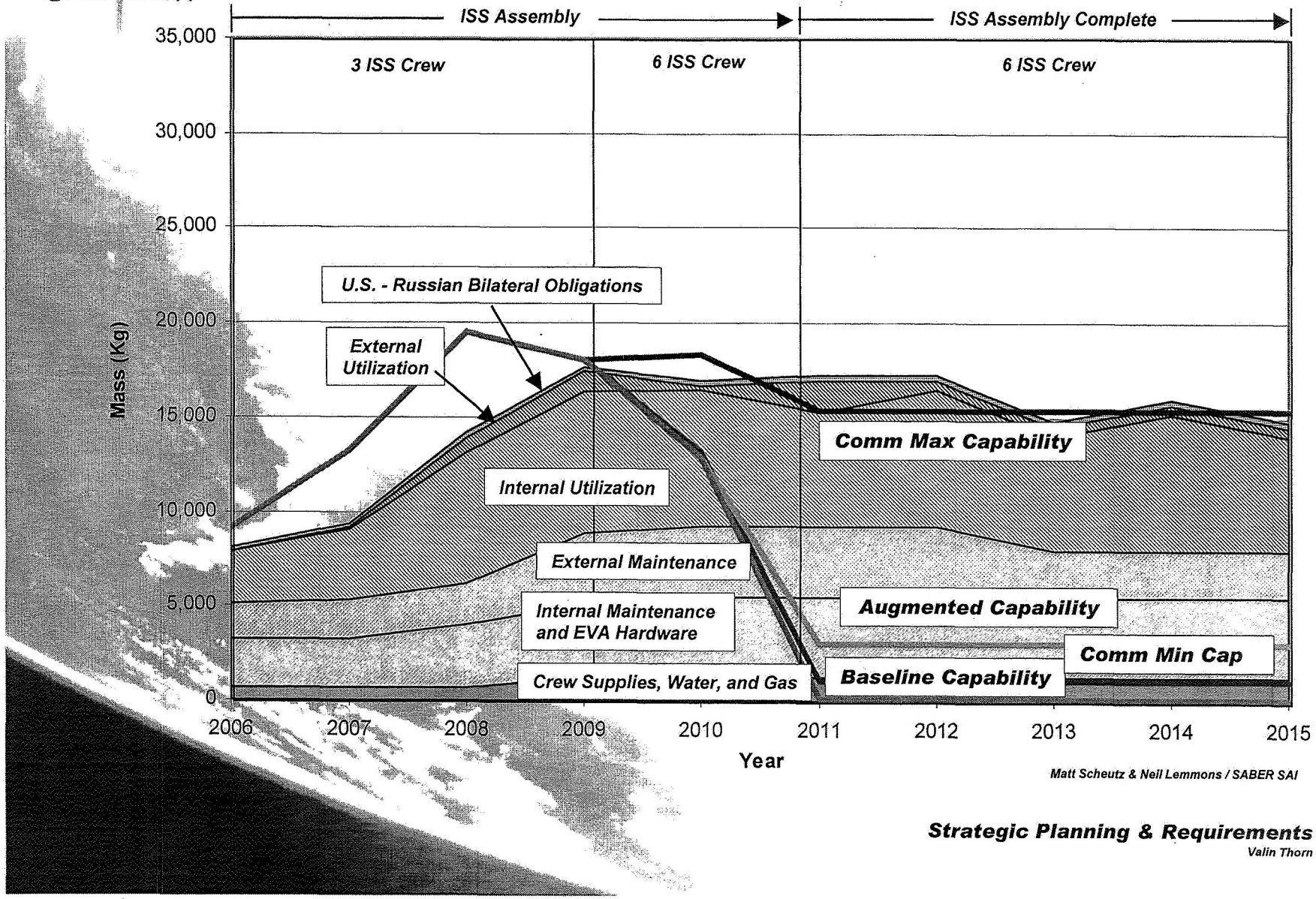
DRAFT

Matt Scheutz & Neil Lemmons / SABER SAI

Strategic Planning & Requirements
Valin Thorn

ISS NASA/JAXA/ESA/CSA Cargo

Return Cargo



DRAFT

Matt Scheutz & Neil Lemmons / SABER SAI

Strategic Planning & Requirements

Valin Thorn

Key ICCS Requirements Summary

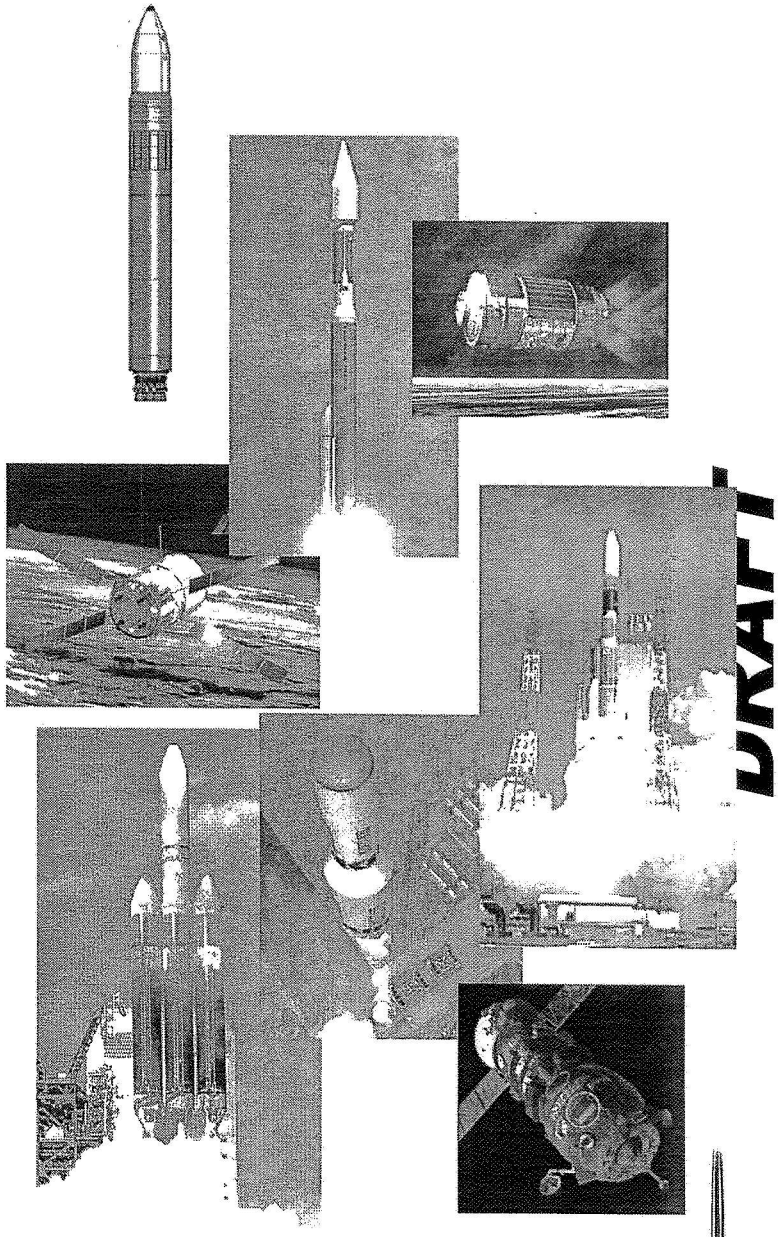
ISS Commercial Cargo Service Requirements Summary	Cargo Delivery				Return Cargo			
					Recoverable		Disposable	
	Internal Cargo (MT/Yr)	External Cargo (MT/Yr)	Water (MT/Yr)	Gas (MT/Yr)	Internal (MT/Yr)	External (MT/Yr)	Internal (MT/Yr)	External (MT/Yr)
Max Requirements	13.4	4.5	0.8	0.4	11	3.3	8.3	2.2
Min Requirements	10.4	2.2	0.8	0.4	1	0	0.4	1.4

Parameter	Launch On Need	Flight Rate	Dock Berth	Stay Time	Power	Late Access	Early Access	EVA & Robotic Capability
Requirement	180 Days	<= 6/yr	US Segment	>=7 Days	500 W Av 1600 W Pk	Lnch- 19 Hrs 200 kg 2 m^3	Ldg+ 4 Hrs 200 kg 2 m^4	Yes

DRAFT

Conclusion

- ***The fundamental requirements necessary to begin acquisition of an ISS Commercial Cargo Service are complete***
  - *The "ICCS Commercial Maximum" satisfies current projections for NASA/JAXA/ESA/CSA cargo delivery demand*
  - *The "ICCS Commercial Minimum" may be acceptable if key risk areas have optimistic outcomes and utilization cargo need is substantially reduced*
- ***ICCS requirements revision planned after official utilization requirements update -- expected in coming weeks***



DRAFT